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# Occupation and the High Risk of Lung Cancer in Northeast Florida

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**A case–control study involving interviews with 321 male patients with lung cancer and 434 controls, or their next of kin, was undertaken to identify reasons for the high lung cancer mortality along the northeast coast of Florida. In Duval county (Jacksonville), the age-adjusted rate for lung cancer, 1970–1975, among white males was the highest of all urban counties in the United States. Increased risks on the order of 40–50% were associated with employment in the shipbuilding, construction, and lumber/wood industries, particularly among workers with reported exposures to asbestos or wood dust. Excess risks were also linked to fishing and forestry occupations, although the numbers of cases involved were small. Occupational factors did not appear to fully account for the area-wide excess of lung cancer, but no evidence was found to implicate smoking habits, migration patterns, or diagnostic and reporting practices as factors responsible for the exceptional mortality rates.**

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A COUNTY-BY-COUNTY survey of lung cancer mortality in the United States during the period 1950–1969 revealed a clustering of elevated rates along the southeast Atlantic seaboard, primarily among white males, with Duval county (Jacksonville) in Florida having one of the highest rates in the United States.[1–3] Case–control studies in coastal Georgia and Virginia have linked the excess risks of lung cancer in those areas to employment in shipyards, particularly those operating during World War II.[4,5] To identify the factors responsible for the exceptionally high rates of lung cancer in Duval county, a case–control study involving interviews with lung cancer patients or their next of kin was carried out.

## Methods

To update lung cancer mortality statistics reported for the period 1950–1969,[3] mortality rates were computed for the period 1970–1975 by sex, race (white, nonwhite) and age for Duval county, its neighboring counties along the northeast Florida coast (Flagler, St. Johns, and Nassau), and the remaining 3052 counties of the contiguous United States, using data from the National Center for Health Statistics and the Bureau of the Census. Not all deaths for 1972 were recorded at the county level and therefore are not included in the calculations. Methods of calculating age-adjusted rates are described elsewhere.[1]

The case–control study consisted of two components. The first was a hospital-based study in which all male residents of Duval county newly diagnosed with primary lung cancer at one of 13 Jacksonville hospitals during the period April 10, 1978 through April 9, 1979 were prospectively ascertained. Tissue slides were sought for each case and independently reviewed by one of the authors (A.N.). Two controls matched by age (±2 years), race, and hospital were selected for each case from closest (in time) admissions of male county residents to those same hospitals for diagnoses other than lung cancer, chronic respiratory disease, or psychiatric conditions. The second component of the study used mortality files for 1976 at the State Department of Health and Rehabilitative Services to identify cases and controls. The cases were all deaths attributed to primary lung cancer among male residents of Duval, Flagler, St. Johns, and Nassau counties, while an equal number of controls, matched by race, age, and county of residence, were randomly selected from deaths attributed to other causes (excluding lung cancer or chronic respiratory disease).

Identifying information from the death certificates was used to locate next of kin of cases and controls in

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# ʰ Risk of Lung Cancer
# ʒt Florida

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the mortality series for interview. Interviews with patients in the hospital series were sought in the hospital, where feasible, or in the patients' homes. Interviews were conducted by local interviewers under the supervision of a professional survey organization, with interviewers not informed of the case–control status of the study subject. The questionnaire sought information on tobacco consumption, and residential, medical and occupational histories. The name of the employer, job title, and duties performed were asked for each job held for six months or longer. The occupational section of the interview included a checklist of certain industries and materials handled. The industrial data were categorized using a scheme developed for this study based on Standard Industrial Classification codes.[6] Respondents were also asked about antecedent lung diseases (including chronic bronchitis, emphysema, recurrent pneumonia, asthma, pleurisy, and tuberculosis).

The measure of association between variables of interest and lung cancer was the relative risk (RR), approximated by the odds ratio.[7] The data from the hospital and mortality series were analyzed separately, but summary RR combining the results were obtained by the Mantel-Haenszel method.[8]

## Results

During 1970–1975, Duval county had the highest lung cancer mortality rate among white males of any metropolitan county in the nation (Table 1). The annual age-adjusted death rate of $93.2/10^5$ far exceeded the national average of $58.6/10^5$. As shown in Figure 1, rates in Duval county were higher than the United States rates at all ages. The age-adjusted rates among white males in the smaller neighboring counties of Flagler, St. Johns, and Nassau were also high, being 100.9, 72.1, and 103.0, respectively. Mortality from lung cancer among nonwhite males in Duval county was less than among whites, but the rate of 77.7 was in excess of the national rate for nonwhite males of 67.4.

During the one-year period between April 10, 1978 and April 9, 1979, 181 incident cases of primary lung cancer and 342 controls* among male residents were identified from admissions to the 13 Jacksonville hospitals. Review of the mortality register for 1976 revealed 217 deaths attributed to primary lung cancer in the four-county area, 89% from Duval county, while an equal number of deaths from other causes served as controls. The controls in the hospital series represented admissions for other cancers (3%), cardiovascular diseases (37%), digestive diseases (19%), accidents (6%) and other conditions (35%). The controls in the mortality series represented deaths due to other cancers (11%), cardiovascular diseases (67%), digestive diseases (8%), accidents (3%), and other causes (11%).

A total of 807 interviews were completed (84% of the

* Twenty controls were not assigned, eight from one hospital due to inaccessibility of discharge records, 12 corresponding to six cases who decided not to participate in the study.

TABLE 1. Listing of the Ten Metropolitan Counties* in the United States with the Highest Age-adjusted Rates of Lung Cancer Mortality Among White Males, 1970–1975†

| County | Mortality rate (deaths/yr/$10^5$) |
|---|---|
| Duval, FL | 93.2 |
| St. Louis City, MO | 90.9 |
| Baltimore City, MD | 88.4 |
| Chesapeake,‡ VA | 87.2 |
| Orleans, LA | 86.1 |
| Mobile, AL | 83.8 |
| Jefferson, KY | 82.8 |
| James City,§ VA | 80.4 |
| Chesterfield,‖ VA | 79.3 |
| Marion, IN | 77.6 |

* Includes all counties with at least 500,000 person-years of observation among white males during 1970–1975.
† Deaths for 1972 are excluded since not all were ascertained for this year.
‡ Includes the independent cities of Norfolk and Portsmouth.
§ Includes the independent city of Newport News.
‖ Includes the independent city of Richmond.

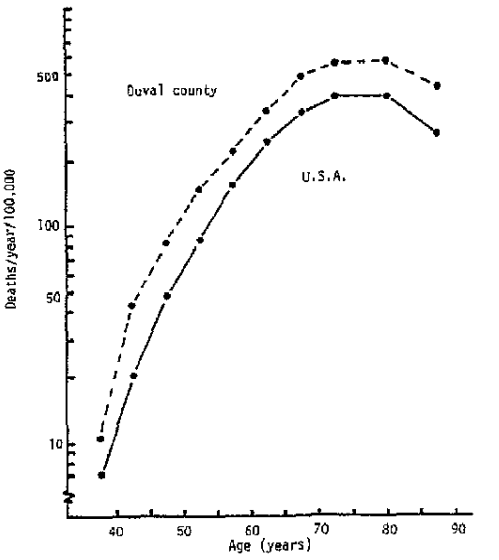


FIG. 1. Lung cancer mortality rates 1970–1975, by age among white males in Duval county and the United States.

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TABLE 2. Numbers of Cases and Controls from the Hospital and Mortality Series According to Age, Race, Education Level, and State of Birth

| | Mortality series | | | | Hospital series | | | |
|---|---|---|---|---|---|---|---|---|
| | Cases | | Controls | | Cases | | Controls | |
| Indicator | No. | % | No. | % | No. | % | No. | % |
| Age | | | | | | | | |
| <50 | 18 | 10.6 | 20 | 12.7 | 14 | 9.2 | 27 | 9.8 |
| 50–59 | 34 | 20.1 | 30 | 38.0 | 49 | 32.2 | 77 | 27.9 |
| 60–69 | 64 | 37.9 | 60 | 38.0 | 53 | 34.9 | 100 | 36.2 |
| 70+ | 53 | 31.4 | 48 | 30.3 | 36 | 23.7 | 72 | 26.1 |
| Race | | | | | | | | |
| White | 132 | 78.1 | 117 | 74.1 | 121 | 79.6 | 217 | 78.6 |
| Black | 37 | 21.9 | 41 | 25.9 | 31 | 20.4 | 59 | 21.4 |
| Education | | | | | | | | |
| <12 | 93 | 55.0 | 80 | 50.6 | 98 | 64.5 | 154 | 55.8 |
| 12+ | 76 | 45.0 | 78 | 49.4 | 54 | 35.5 | 122 | 44.2 |
| State of birth | | | | | | | | |
| Florida | 44 | 26.0 | 39 | 24.7 | 47 | 30.9 | 72 | 26.1 |
| Other southern state | 90 | 53.3 | 80 | 50.6 | 67 | 44.1 | 133 | 48.2 |
| Elsewhere | 35 | 20.7 | 39 | 24.7 | 38 | 25.0 | 71 | 25.7 |

target sample) with the response rate somewhat higher for cases (86%) than controls (83%). In the hospital series the next-of-kin provided a higher percentage of interviews for cases (42%) than controls (13%), because lung cancer is often rapidly debilitating and fatal. For this reason, analyses stratified the hospital series with respect to the type of respondent (self *versus* next-of-kin) unless such division resulted in exceptionally small sample sizes. The next-of-kin interviews in both series were most often (71% for both cases and controls) conducted with the wives of the study subjects. Of the total number interviewed, ten were excluded because of unsatisfactory completion of the questionnaires. An additional 42 who were short-term, *i.e.*, less than five-year residents in northeastern Florida were also deleted, bringing the final study group to 755 subjects, 321 cases and 434 controls.

Table 2 shows the distribution of cases and controls according to age, race, educational level, and state of birth. Subjects in the hospital series were younger (median, age 63 years) than subjects in the mortality series (median, age 65 years), but cases and controls

TABLE 3. Relative Risk (RR) of Lung Cancer for Ever Employment in 15 Industrial Categories According to Source of Ascertainment and Type of Respondent

| | Source of ascertainment (respondent type) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mortality | | | Hospital (next of kin) | | | Hospital (self) | | | Summary |
| Industry | Case | Control | RR* | Case | Control | RR* | Case | Control | RR* | RR |
| Agriculture | 51 | 34 | 1.6 | 22 | 9 | 1.6 | 27 | 78 | 0.9 | 1.3 |
| Forestry | 4 | 3 | 1.3 | 0 | 1 | — | 5 | 1 | 14.3 | 2.3† |
| Fishing | 5 | 1 | 4.8 | 0 | 1 | — | 4 | 2 | 5.6 | 3.2† |
| Construction | 58 | 48 | 1.2 | 16 | 9 | 1.0 | 35 | 63 | 1.8 | 1.4† |
| Lumber/wood | 14 | 10 | 1.3 | 7 | 2 | 2.1 | 14 | 26 | 1.5 | 1.5 |
| Metal | 22 | 18 | 1.2 | 15 | 4 | 2.6 | 14 | 38 | 1.0 | 1.2 |
| Shipbuilding | 35 | 25 | 1.4 | 15 | 5 | 2.0 | 21 | 44 | 1.4 | 1.5† |
| Paper/pulp | 5 | 10 | 0.5 | 4 | 0 | | 5 | 12 | 1.1 | 0.9 |
| Chemical, misc. mfg. | 31 | 35 | 0.8 | 11 | 10 | 0.6 | 31 | 80 | 1.1 | 0.9 |
| Transportation | 77 | 67 | 1.1 | 36 | 18 | 1.4 | 49 | 129 | 1.1 | 1.1 |
| Wholesale/retail | 58 | 74 | 0.6 | 19 | 18 | 0.4 | 41 | 138 | 0.6 | 0.6‡ |
| Personal service | 21 | 27 | 0.7 | 11 | 8 | 0.8 | 13 | 43 | 0.8 | 0.7 |
| Professional | 82 | 68 | 1.3 | 28 | 12 | 1.6 | 44 | 122 | 1.0 | 1.2 |
| NEC | 17 | 11 | 1.5 | 3 | 5 | 0.3 | 7 | 12 | 1.6 | 1.2 |
| Military | 65 | 54 | 1.2 | 24 | 12 | 1.3 | 40 | 110 | 1.0 | 1.1 |

* All risks are relative to those never employed in the industry.
† $P < 0.05$ (one-sided).
‡ $P < 0.01$ (one-sided).

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TABLE 4. Relative Risk (RR) of Lung Cancer Associated with Employment in Selected Industries According to Cigarette Smoking Category

| | | Smoking category | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Non, <½ pk/day | | | ½–1 pk/day | | | >1 pk/day | | |
| Industry | Ever employed | Case | Control | RR* | Case | Control | RR* | Case | Control | RR* |
| Shipbuilding | No | 17 | 110 | 1.0 | 117 | 132 | 6.9 | 91 | 92 | 7.7 |
| | Yes | 5 | 18 | 2.7 | 33 | 37 | 7.2 | 32 | 17 | 14.4 |
| Construction | No | 14 | 97 | 1.0 | 101 | 112 | 6.2 | 77 | 83 | 6.3 |
| | Yes | 8 | 31 | 1.5 | 49 | 57 | 6.1 | 46 | 26 | 13.5 |
| Lumber/wood | No | 21 | 115 | 1.0 | 130 | 155 | 5.1 | 110 | 100 | 6.5 |
| | Yes | 1 | 13 | 0.6 | 20 | 14 | 10.6 | 13 | 9 | 14.7 |
| Wholesale/retail | No | 17 | 62 | 1.0 | 99 | 75 | 5.4 | 69 | 50 | 5.7 |
| | Yes | 5 | 66 | 0.3 | 51 | 94 | 2.6 | 54 | 59 | 4.1 |

* All risks are adjusted for source of ascertainment and are relative to those for men who were in the smoking category consisting of nonsmokers and smokers of less than one-half pack (pk) per day and who were never employed in the particular industry.

in each series were similar in age and race because of the matching employed in the design. The cases tended to have fewer years of formal education than the controls, and were somewhat more often born in the state of Florida. However, differences according to duration of residence in the Jacksonville area were small and not statistically significant.

Table 3 lists the RR according to *ever* employment in each of 15 industrial categories. Among the major industries in the area, 40–50% elevations in risk were associated with shipbuilding, construction, and lumber/wood employment, while decreases in risk were found for wholesale/retail trades. There was considerable overlap among the former three industries. About 40% of the men ever employed in the shipbuilding or the lumber/wood industries also worked at some time in construction. Elevated risks, however, were seen among those with no construction employment (RR = 1.5 for shipbuilding, RR = 1.6 for lumber/wood), while an increased risk associated with construction work (RR = 1.3) was found among those with no history of shipbuilding or woodworking jobs. RR of 3.2 and 2.3 were found for *ever* employment in the fishing and forestry industries, respectively, but the numbers of individuals involved were small. The RR for *usual* employment in the 15 industrial groups, *i.e.*, the industry where an individual worked the longest number of years, showed similar patterns.

Table 4 shows the RR for selected industries according to levels of cigarette smoking. The higher risks associated with shipbuilding were seen in each smoking category, but the largest absolute excess risk was among heavy smokers. The summary RR adjusted for smoking and source/respondent status was 1.4 (one-sided *P*

TABLE 5. Relative Risk (RR) of Lung Cancer by Number of Years Worked in Shipbuilding, Construction and Lumber/Wood Industries According to Source of Ascertainment

| | | Source of ascertainment | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mortality series | | | Hospital series | | | Summary |
| Industry | Years employed | Case | Control | RR | Case | Control | RR | RR |
| Shipbuilding | Never | 134 | 133 | 1.0 | 116 | 227 | 1.0 | 1.0 |
| | 1–9 | 24 | 21 | 1.1 | 26 | 39 | 1.3 | 1.2 |
| | 10+ | 8 | 4 | 2.0 | 8 | 9 | 1.7 | 1.8 |
| | UK | 3 | 0 | — | 2 | 1 | — | — |
| Construction | Never | 111 | 110 | 1.0 | 101 | 204 | 1.0 | 1.0 |
| | 1–9 | 24 | 19 | 1.3 | 28 | 39 | 1.5 | 1.4 |
| | 10+ | 32 | 29 | 1.1 | 21 | 33 | 1.3 | 1.2 |
| | UK | 2 | 0 | — | 2 | 0 | — | — |
| Lumber/wood | Never | 155 | 148 | 1.0 | 131 | 248 | 1.0 | 1.0 |
| | 1–9 | 11 | 7 | 1.5 | 14 | 22 | 1.2 | 1.3 |
| | 10+ | 2 | 2 | 1.0 | 6 | 6 | 1.9 | 1.6 |
| | UK | 1 | 1 | — | 1 | 0 | — | — |

UK: unknown duration.

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TABLE 6. Relative Risk (RR) of Lung Cancer Associated with Employment in the Shipbuilding and Construction Industries According to Reported Exposure to Asbestos and Type of Respondent

| | | | Type of respondent | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Next-of-kin | | | Self | | | Summary |
| Industry | Ever employed | Asbestos exposure | Case | Control | RR | Case | Control | RR | RR |
| Shipbuilding | No | — | 183 | 165 | 1.0 | 67 | 195 | 1.0 | 1.0 |
| | Yes | No | 39 | 27 | 1.3 | 12 | 30 | 1.2 | 1.3 |
| | | Yes | 11 | 3 | 3.3 | 9 | 14 | 1.9 | 2.3 |
| Construction | No | — | 159 | 138 | 1.0 | 53 | 176 | 1.0 | 1.0 |
| | Yes | No | 59 | 53 | 1.0 | 24 | 45 | 1.8 | 1.2 |
| | | Yes | 15 | 4 | 3.3 | 11 | 18 | 2.0 | 2.5 |

= 0.06), with 90% confidence limits of 0.99–1.90. The RR for construction and lumber/wood employment were not elevated in every smoking category, but the decreases associated with wholesale/retail trades were consistently observed. The summary RR and corresponding one-sided *P*-values and confidence limits were 1.4 ($P = 0.04$; 1.03–1.8) for construction, 1.7 ($P = 0.04$; 1.04–2.7) for lumber/wood, and 0.5 ($P < 0.001$; 0.40–0.70) for wholesale/retail. The percentage of smokers among the small number of the men employed in forestry or fishing occupations was not elevated.

Most of the men employed in shipbuilding worked in the industry for limited periods, often during World War II. Only 20% were employed for at least ten years, but among these the RR reached 1.8 (Table 5). The RR associated with lumber/wood jobs was also somewhat higher among the minority who worked ten or more years, while no trend according to duration of employment was detected for the construction industry. The RR for these industries were also calculated according to age, race, education level, and duration of residence in northeast Florida. There were no consistent trends in the RR with age. The RR for shipbuilding were higher in blacks than whites, among those with less than a high school education, and among long-term (35+ years) residents. The elevated RR for construction jobs were limited to those with less than 12 years education.

In the checklist of materials handled at work, the RR was about two for persons exposed to asbestos or wood dust. The relative excess risk was independent of source of ascertainment, although self-respondents reported considerably higher exposure rates than next-of-kin; among the controls, 15% of self-respondents *versus* 4% of next-of-kin reported asbestos exposures, with corresponding percentages of 18% *versus* 10% for wood dust. As shown in Table 6, asbestos exposures accounted for much of the higher RR associated with shipbuilding and construction. The excess for lumber/wood jobs was primarily among workers with wood dust exposures (RR = 1.9) than among those without (RR = 1.2).

Table 7 shows the RR of different histologic types of lung cancer for the selected industrial groups and exposures using data from the hospital series (based on classifications of Jacksonville pathologists). The slide review revealed that all cases were consistent with the diagnosis of lung cancer. There was agreement as to histologic type for 78% of the cases, with our review indicating a smaller percentage of squamous cell and unspecified carcinomas, and a larger percentage of adenocarcinoma and anaplastic small cell and large cell carcinomas. The increased risks for construction, ship-

TABLE 7. Relative Risk (RR) for Histologic Types of Lung Cancer Associated with Employment in the Construction, Shipbuilding, and Lumber/Wood Industries, and Reported Exposures to Wood Dust and Asbestos from the Hospital Series

| Indicator | | Controls | Squamous | RR | Small cell anaplastic | RR | Adeno-carcinoma | RR | Others and unspecified | RR |
|---|---|---|---|---|---|---|---|---|---|---|
| Industry | | | | | | | | | | |
| Construction | No | 202 | 36 | 1.0 | 15 | 1.0 | 24 | 1.0 | 26 | 1.0 |
| | Yes | 71 | 15 | 1.2 | 10 | 1.9 | 10 | 1.8 | 16 | 1.9 |
| Shipbuilding | No | 225 | 38 | 1.0 | 19 | 1.0 | 26 | 1.0 | 33 | 1.0 |
| | Yes | 48 | 13 | 1.6 | 6 | 1.5 | 8 | 1.4 | 9 | 1.2 |
| Lumber/wood | No | 246 | 42 | 1.0 | 22 | 1.0 | 30 | 1.0 | 37 | 1.0 |
| | Yes | 27 | 9 | 2.0 | 3 | 1.2 | 4 | 1.2 | 5 | 1.2 |
| Exposures | | | | | | | | | | |
| Wood dust | No | 226 | 41 | 1.0 | 15 | 1.0 | 28 | 1.0 | 32 | 1.0 |
| | Yes | 47 | 10 | 1.2 | 10 | 3.4 | 6 | 1.1 | 10 | 1.5 |
| Asbestos | No | 236 | 44 | 1.0 | 17 | 1.0 | 26 | 1.0 | 36 | 1.0 |
| | Yes | 37 | 7 | 1.0 | 8 | 3.0 | 8 | 2.0 | 6 | 1.1 |

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TABLE 8. Relative Risk (RR) of Lung Cancer Associated with Prior History of Chronic Lung Disease According to Type of Respondent

| | Type of respondent | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Next-of-kin | | | | Self | | | |
| | Number reporting disease | | | | Number reporting disease | | | |
| Antecedent lung disease | Case | Control | RR | RR* | Case | Control | RR | RR* |
| Emphysema | 70 | 26 | 2.8 | 2.1 | 19 | 31 | 1.9 | 1.4 |
| Chronic bronchitis | 28 | 16 | 1.5 | 1.3 | 8 | 22 | 1.0 | 0.7 |
| Pleurisy | 23 | 13 | 1.5 | 1.2 | 10 | 21 | 1.3 | 1.2 |
| Asthma | 18 | 6 | 2.6 | 2.8 | 3 | 22 | 0.4 | 0.3 |

* Relative risk of lung cancer associated with prior occurrence of the particular lung disease adjusted for cigarette smoking category.

building, and lumber/wood occupations did not seem specific for particular cell types. However, there were higher risks for small cell carcinoma following exposures to wood dust (RR = 3.2) and asbestos (RR = 3.0).

In response to questions on chronic respiratory illnesses, 32% of the controls (in both the next-of-kin and self terviews) responded positively, compared to 53% and 47% of the cases, respectively. Emphysema was more closely associated with lung cancer than were the other lung diseases most often listed, *i.e.*, chronic bronchitis, pleurisy, and asthma (Table 8). The RR for emphysema were as high or higher for both self and next-of-kin respondents who reported emphysema prior to 1970, *i.e.*, at least six years prior to the onset of cancer, than after 1970. The magnitude of the association with emphysema was reduced when cigarette smoking was taken into account, but the positive link still remained. The smoking and respondent-adjusted RR of lung cancer associated with antecedent emphysema was 1.9 (one-sided $P < 0.001$ with 90% confidence limits, 1.5–2.4). The reporting of emphysema was higher among both cases and controls who had worked in construction or shipbuilding jobs, but the elevated RR of lung cancer associated with these industries were observed among men with and without reported emphysema.

## Discussion

The patterns of cancer mortality by county during the period 1950–1969 revealed a cluster of elevated rates for lung cancer along the southeast Atlantic coast.[1-3] Our updated statistics for northeastern Florida counties show that the excess in this region has become more pronounced in 1970s. Indeed, lung cancer mortality among white males in Duval county in the period 1970–1975 was the highest recorded among all metropolitan counties of the United States, and was greater than the national average by more than 50%. Mortality was also elevated among blacks, but not to as great an extent.

The elevated risks associated with employment in shipbuilding, construction, and wood-related industries suggest that occupational exposures account for at least part of the high lung cancer mortality among male residents of northeast Florida. The RR for these industries are not high enough, however, to fully account for the area-wide excess among white males, but no other factors could be implicated in this study. The percentage of controls who smoked cigarettes was somewhat higher than the national average,[9] but the controls included persons hospitalized or deceased from conditions known to be related to smoking. The authors recently completed a population-based telephone survey in Georgia indicating no difference in the percent of cigarette smokers (ever or current) among coastal *versus* inland white male residents aged 45 and older, and the percent of smokers in the Jacksonville controls resembled the Georgia statewide average. The excess lung cancer in northeast Florida does not seem related to the influx of residents from outside the area, since no consistent gradients were observed with duration of residence; risks were in fact slightly higher among those born in the state than elsewhere. It is difficult to evaluate local variations in diagnostic and reporting practices, but the clustering of elevated mortality from lung cancer extends beyond Jacksonville to involve most of the southeast Atlantic coast, with a gradual reduction in rates towards the inland counties. Furthermore, an independent pathologic review uncovered no misdiagnoses of lung cancer, so that overreporting was not a problem in this area. General environmental factors, *e.g.*, sulfate air pollution, excessive humidity, and radon exposures in homes and buildings may be involved, but additional study using a different approach would be required to evaluate such potential risk factors.

The relation of shipbuilding to lung cancer has now been observed in three areas along the southeast Atlantic coast: Georgia,[4] the Norfolk-Newport News region of Virginia,[5] and the Jacksonville area of Florida. Interview studies in the first two areas found increased risks of lung cancer, on the order of 60–70% after taking smoking into account, associated with employment in the shipbuilding industry during World War II. In all three instances a sizable percentage (20–35%) of the

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cases were employed in area shipyards, often for only limited periods during the 1940s. In Jacksonville employment reached a war-time peak of about 20,000, then dropped to less than 2000 in the 1950s and thereafter.[10,11]

The elevated risk associated with shipbuilding in this study was mainly among those reportedly exposed to asbestos. Some excess was found among those without exposures reported, but the differences in direct *versus* next-of-kin interviews suggest that knowledge of exposure by the next of kin may be incomplete. The workers themselves may also have been unaware of asbestos exposure. Only a minority of those employed in shipbuilding were said to have worked with asbestos materials, but asbestos was extensively used in insulation and fireproofing in large ships and inadvertant exposure appears to have been widespread.[12] In northeast Florida, as well as coastal Georgia and Virginia, the excess risk of lung cancer among shipyard workers was greatest among heavy cigarette smokers, consistent with the syngeristic interaction described for asbestos exposure and smoking.[13]

Only a few cases of asbestosis or mesothelioma were found through pathology and diagnostic index reviews at the participating hospitals in the Jacksonville area. This resembles the situation in Georgia, in contrast to the 15-fold excess of mesothelioma among shipyard workers in Virginia.[14] It is not clear whether this regional variation in mesothelioma reflects diagnostic practices or differences in asbestos exposure, *e.g.*, intensity or type of fiber. Each region was involved in the construction of large ships (mainly liberty cargo vessels in Florida and Georgia and combatant naval ships in Virginia) requiring great amounts of asbestos materials. The shipbuilding industries in Florida and Georgia, however, began operations during World War II, while the industry was established in coastal Virginia prior to World War I.[15] Since asbestos-induced mesothelioma is characterized by latent periods of 35 years and more, the increase is perhaps yet to be seen among former workers in Florida and Georgia. In contrast, the shorter latent periods for asbestos-induced lung cancer[16] have already permitted recognition of an excess in all three states.

The small elevation in RR associated with construction may also be related to asbestos exposure, which was reported by about 30% of the construction workers who were directly interviewed. A death certificate survey in coastal Georgia found construction mentioned as the usual industry about twice as often for deaths attributed to lung cancer,[17] although some of those men also had prior shipyard employment.[4] In our study, the excess risk associated with construction work persisted after adjusting for smoking habits and employment in shipyards. The findings are consistent with previous case-control studies[18,19] and occupational mortality surveys,[20-24] although limited in nature, which have suggested an increased risk of lung cancer in construction workers. Asbestos has been a suspected agent,[25] although polycyclic hydrocarbons appear involved in some categories of work such as roofers.[26]

The small elevation in risk for workers in the lumber/wood industry (primarily sawmill laborers) was mainly among those with wood dust exposure, reported by about two-thirds of those directly interviewed. Nasal cancer is a well-established disease among furniture makers, especially those with exposure to hard wood dusts,[27] and a relationship to laryngeal cancer has also been reported.[28] This industry was recently implicated in a small case-control study of lung cancer in Sweden,[29] but excess lung cancer has not generally been reported among furniture makers, sawmill workers, lumbermen, or others handling wood products.[30] Among death certificates for lung cancer in coastal Georgia, there was an excess frequency of wood-related occupations, principally in rural areas.[17] These occupations also included forestry jobs, a separate category in our survey where risk was also significantly elevated. The excess risk associated with lumber/wood employment was limited to smokers, raising the possibility of a co-carcinogenic effect.

The increased risk for the occupation of fishing, although based on small numbers, has been reported in other surveys.[21,22] Reasons for this association are unknown. It is also noteworthy that lung cancer was not related to work in the paper and pulp industry. This confirms the findings in coastal Georgia[4] and suggests that the excess mortality from lung cancer reported in countries with a concentration of paper or pulp mills[2] is unrelated to employment in this industry.

A decreased risk of lung cancer was observed among men who held jobs in wholesale or retail sales. The deficit was not accounted for by lower smoking levels, but whether it is related to the "cleaner" work environment or to other factors is not clear. Under the assumption that workers in clerical jobs (including many in the sales industry) are unlikely to be exposed to occupational carcinogens, one case-control survey of hospitalized patients in Buffalo estimated the risks of cancer for various occupations relative to the risks for clerical workers.[31] This procedure, not done in our survey, would have increased the magnitude of the RR for each of the high-risk industries.

Although it is difficult to disentangle the effects of smoking, chronic obstructive lung disease has been reported to predispose to lung cancer.[32] The connection between emphysema and lung cancer observed in our study was only partly accounted for by the relation of both diseases to cigarette smoking. Emphysema was more often reported for cases and controls who had worked in the shipbuilding and construction industries. Thus, although this study was not designed to identify

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risk factors for emphysema, nor to verify its occurrence, there is the possibility of occupational components common to both diseases. It is of interest that chronic obstructive lung disease and lung cancer have been reported to cluster in families,[33] suggesting a familial predisposition to both diseases. Since mortality from emphysema is relatively high among white males along the northeast Florida and Georgia coasts,[34] it is possible that chronic pulmonary disease and its determinants have contributed to the area's excess cancer rates for lung cancer.

Difficulty in recall by the patients and lack of knowledge by their next of kin limited the amount of detail about occupational and other exposures, although probably not differentially between the cases and controls. Validation studies in other populations suggest that proxy respondents can provide adequate data on broadly defined variables, including smoking category and usual occupation,[4,35,36] and the RR estimates in the present study were similar for self and next-of-kin respondents.

Despite methodologic limitations, this case-control study in the Jacksonville area of Florida extends previous studies indicating that work in the shipbuilding industry, particularly during World War II, is at least partly responsible for the clustering of lung cancer along the southeast Atlantic coast. Increased risks were also associated with the construction and lumber/wood industries, which may contribute to the exceptionally high rates of lung cancer in northeast Florida. It seems likely that nonoccupational factors are also involved, but this study yielded no evidence that smoking habits, migration patterns, or diagnostic and reporting practices contributed to the area-wide excess of lung cancer.

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